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The Response of Potato to Differences in the Watering Intervals and Composition of the Growing Media in the Medium Plains

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Abstract: ***The cultivation of potatoes in the medium land is constrained by low air humidity and high temperatures which causes a lack of water availability due to the high evapotranspiration. Therefore, watering intervals and growing media compositions are needed that can support the growth of potato plants. This research was conducted to determine the effect of the interaction between watering intervals and growing media compositions on the growth and yield of potato cv. Medians in medium land. The research was conducted at the Research Station Ciparanje Jatinangor, Faculty of Agriculture, Universitas Padjadjaran (±685 m above sea level), . The experimental was using Split Plot Design consisted of two factors. The main plot factor was the watering intervals, consisted of 3 levels. The sub-plot factor was the growing media compositions, consisted of 4 levels. The experimental results showed that there were some effects of no interactions between watering intervals and growing media compositions on the , plant height, leaf area indexs, khlorophylconten, stomata conductance and leaf water contenrelatif. Growing media composed of soil, compost, charcoal, cocopeat (4:1:1:1) showed plant heigt, leaf area index, stomatal conductance, leaf relative water content, were higher than other treatments. Watering intervals of 2 days gave the highest plant height and stomatal conductance.***

Keywords: potato, growing media compositions, watering intervals, medium land

1. Introduction

Potato (*Solanum tuberosum* L.) is one of the horticultural plants that have high carbohydrate content. As Indonesia's population growth, the demand for potato commodities has also increased. Increasing the needs of potatoes is caused by the development of potato-processing industry and the shifting consumption patterns of society who started to consume potatoes both as a vegetable or processed food[1]. It can be seen from the consumption of potatoes per capita/year that showed an increase in the year 2014 that is 1.460 kg to 2.242 kg in 2017[2].

The demand for potato commodities could not be fulfilled because the production of potatoes decreased in 2014 as much as 1,347,818 tons to 1,164,738 tons in 2017[2]. One of the causes is the decrease in potato area harvested because the cultivation of potatoes is still focused on the highlands. The potato cropping area can be expanded by plant potatoes in the medium plain, but it is constrained by the low air humidity and high temperature that causes water deficit due to high evapotranspiration process.

Water is essential for plants because water serves as a solvent and food nutrient carrier, and affect the opening and closing of stomata[3]. Water deficit inhibits potato growth and yield. Therefore, it is necessary to inform about watering intervals that can meet crop water requirements so that the growth and yield of potatoes can be optimal.

Inceptisols are commonly found in medium lands of Jatinangor have low nutrient availability as well as less fertile soil that is unsuitable for potato growth and development. Loose, crumb structure, well-drained soil high in organic matter are ideal conditions for potatoes. The use of a mixture of organic materials such as charcoal, cocopeat and compost as a substituent component of growing media is expected to support the growth and yield of potatoes.

The use of organic material into the growing media would increase the water holding capacity, so that water can be available longer for the plant[4]. Growing media that mixture of soil and compost able to improve the physical structure and biology of soil, and increase the soil water holding capacity. Compost is also able to increase and provide nutrients for plants in Inceptisols soil[5].Potato growing media consisting of a mixture of soil with charcoal husk can improve drainage. The addition of charcoal husk in potato growing media resulting in 28.2 % tuber yield increase when compared to non-rice husks added soil[6].Growing media mixed with cocopeat has micropores that can inhibit more water movement, causing higher water availability. Cocopeat has good physical properties, a huge water holding capacity which is 69%, many pore space and low bulk density[7].

2. Materials & Methods

2.1 Preparation of plant materials and cultivation

The research was conducted in the Research Station Ciparanje Jatinangor, Faculty of Agriculture, Universitas Padjadjaran, West Java with a height of ± 685 m above sea level.

The tools used in this study are: (1) measuring cylinder, (2) thermohygrometer, (3) leaf porometer, (4) tape-meter, (5) analytical scale, (6) chlorophyll meter, (7) aluminium foil, (8) label paper,(9) stationery.The materials used in this study are: (1) potato seeds of G2 Medians cultivar (30-40g/tuber), (2) Inceptisols Jatinangor soil, (3) husk charcoal, (4) cocopeat, (5) compost, (6) polybags of size 35 cm × 35 cm,

(7) plastic shade, (8) silver-black mulch, (9) N, P, K (Urea, SP-36, and KCl) fertilizers, (10) 3G Furadan, (11) Basamid 98 GR, (12) insecticide Curacron 500 EC, and (13) bactericide Plantomycin.

This experimental used a Split Plot Design consisted of two factors. The main plot factor was the watering intervals, consisted of 3 levels (watering intervals of 3,4, and 5 days). The sub-plot factor was the growing media compositions of soil, compost, husk charcoal (1:1:1); soil, compost, husk charcoal (2:1:1);soil, compost, cocopeat (1:1:1); and soil, compost, cocopeat (2:1:1).There were 12 treatments with 3 replications on each until 36 units of the experiment were gained. Every unit consisted of six plants inside provided polybag, so there were 216 experimental plants.

The growing media used is soil, compost, cocopeat, and hush charcoal. These materials mixed up evenly using a hoe according to the treatment that has been determined. Then the media is sterilized chemically using Basamid 98 GR and put into polybagssize of 50 x 50 cm, and then was incubated for 2 weeks. Second generation (G2) of potato tuber cv. Medians (10-20g/tuber) were planted in ± 7 cm depth and the covered with the growing media. 0.8 g plant^{-1} of 3G furadan was spread around the seed to avoid the soil insects. During the cultivation process, about 300 kg ha^{-1} (4.5 g plant^{-1}) of N fertilizer was given twice at 7 days after planting and 30 days after planting. While 100 kg ha^{-1} (3.0 g plant^{-1}) of K and 150 kg ha^{-1} (4.5 g plant^{-1}) of P fertilizer were given at one time at 7 days after planting.

Watering is carried out byeach watering interval treatments (3, 4, and 5 days). Watering is carried out until the growing media reached field capacity condition using a measuring cup. Spraying Curacron 500 EC and bactericide Plantomycin were aimed to control insects and pests. The harvest time for Medians potatoes is 100-110 days after planting. Harvesting could be started when the leaves have a yellowish colour that is not caused by disease and the stems of plants became yellowish.

2.2 Plant growth and yield analysis

The physical properties of each growing media compositions were analyzed before planting consisted of media density, porosity, air space, and water retention capacity.

Plant height, stomatal conductance, leaf area index, chlorophyll content, dry weight, leaf relative water content, and shoot-root ratio were evaluated as plant growth characters. Whereas, the number of stolons per plant, stolon tuberization, number of tubers per plant, tubers weight per plant, percentage of potatoes qualified and not qualified market, and percentage of potatoes based on quality grade were evaluated as yield characters.

2.3 Statistical analysis

All parameters were tested by two-way of analysis of variance (ANOVA). If the treatment shows effect significantly, Duncan multiple range test (DMRT) at 5% significance level will be applied to analyze the differences among the treatments.

3. Result & Discussion

Growing media physical properties

Based on the analytical result on physical properties of the growing media compositions, it showed that compositions of soil, compost, husk charcoal (2:1:1) has the highest density but has water retention capacity and percentage of porosity at its lowest compared to other treatments (Table 1). Compositions of soil, compost, husk charcoal (1:1:1) has the highest air space because it has high porosity. The growing media composition with high air space able to provide sufficient oxygen for plant growth.

Table 1: Growing media physical properties

Growing media	Media density (kg/L)	Porosity (%)	Air space (%)	Water retention capacity (%)
m_1	0.66	50.30	12.50	37.80
m_2	0.70	46.20	9.70	36.50
m_3	0.55	49.50	7.50	42.00
m_4	0.66	49.40	6.50	42.90

Description: m_1 = soil, compost, husk charcoal (1:1:1), m_2 = soil, compost, husk charcoal (2:1:1), m_3 = soil, compost, cocopeat (1:1:1), m_4 = soil, compost, cocopeat (2:1:1)

Leaf Area Index and Chlorophyll Content

Based on the results of statistical showedno interaction between watering intervals and growing media compositions on leaf area index and chlorophyll content.

Table 2: Effect of watering intervals and growing media compositions on leaf area index and chlorophyll content

Treatments	Leaf Area Index	Chlorophyll Content
s_1 = watering interval of 3 days	2.26	40.59
s_2 = watering interval of 4 days	1.91	41.30
s_3 = watering interval of 5 days	1.99	38.16
m_1 = soil, compost, husk charcoal (1:1:1)	1.85	39.48
m_2 = soil, compost, husk charcoal (2:1:1)	2.20	42.35
m_3= soil, compost, cocopeat (1:1:1)	2.06	40.06
m_4 = soil, compost, cocopeat (2:1:1)	2.08	38.19

The larger the leaf area index indicates the position between the canopy of plants that are far apart. The too-wide planting distance lowers the effectiveness of land use, resulting in decreased productivity[8]. The smaller the leaf area index also does not describe every plant is effective in absorbing the energy of the sun. It is because it describes the position between the canopy cover each other so that the leaves cannot get full sunlight and inhibits the photosynthesis process.

One of the factors affecting chlorophyll synthesis is water availability[9]. Water deficit will inhibit the absorption of nutrient elements, especially nitrogen and magnesium that plays an important role in the chlorophyllsynthesis[10].

Plant height, Stomatal Conductance, Leaf Relative Water Content, and Shoot-root Ratio

Based on the results of statistical analysis showed there was no interaction between watering intervals and growing media compositions on plant height, stomatal conductance, leaf relative water content, and shoot-root ratio.

At 42 days after plant, the composition of the soil, compost, husk charcoal (1:1:1) has lower plants height compared to m_2 and m_3(Table 3).This can be due to the m_1 percentage of porosity is high while the water retention capacity is low so that it causes high water loss. The reduced water supply from the growing media resulted in the uptake of water into the plant through the roots also reduced, so that water content in all plant organs decreased, including the leaves. It causes a declining photosynthesis rate. This leads to the growth of the crown of the plant becomes stunted and the plant becomes short. While on the composition of growing media m_2 and m_3 of water availability for the plant is fulfilled. The availability of sufficient water to facilitate the roots to absorb nutrients that will be transported to vegetative parts of the plant so that the vegetative growth can be more optimal.

Data in Table 3 shows that the longer the watering interval to cause the stomatal conductance decreases. It means the decline of the stomatal conductance in line with the decreasing water content in the growing media.The watering interval of 5 days (s_3) resulted in the lowest stomatal conductance because the plant lacked water. Water deficitcauses the water distribution to the cells of the guard is decreased resulting in a decrease in turgor pressure which has an impact on stomatal closure[11]. Growing media $m_3$and m_4 have the highest stomatal conductance because both use cocopeat as its mixed material. Cocopeat has high water retention capacity manages to supply enough water for plants.

The leaf relative water content can be used as a physiological indicator of water status on the leaves, it shows the balance between the water supply to the leaf tissue and the transpiration level[12]. Data in Table 3 shows that the growing media containing a mixture of cocopeat has high water retention capacity so that the availability of water is also high thus the rate of water absorption will be optimal and can compensate for the rate of transpiration. The relative water content of the leaves always interacts with stomata conductance on water shortages[13]. In the treatment of m_1 and m_2 which have low stomatal conductance indicates the plant is deficient in water because of lack of water supply from the growing media. Lack of water supply that can be absorbed by plants resulted in leaf relative water content also getting lower. Water shortages cause the shoot-root ratio to be lower. Data in Table 8 shows the growing media composition of m_1 and m_2 resulting in a lower shoot-root ratio compared to the m_4. One of the responses of plants to drought stress is to change the assimilate distribution which prioritizes root growth over the plant canopy so that it can increase the ability of water absorption and maintain osmotic pressure, while transpiration from the top of the plant decreases[14].

Dry Weight

The result of variance analysis showed that there is an interaction between watering intervals and growing media compositions to dry weight.

Table 4: Effect of watering intervals and growing media compositions on dry weight (g)

Watering Intervals	Growing Media Compositions			
	m_1	m_2	m_3	m_4
s_1	19.47 b	16.83 a	16.41 a	17.34 a
	A	A	A	A
s_2	18.02 b	18.81 a	15.29 a	12.52 a
	B	B	AB	A
s_3	13.17 a	15.37 a	19.96 b	15.28 a
	A	A	B	A

Mean values in each column with the same letter are not significantly different (p=0.05) based on DMRT. Small case letters are read vertically and capital letters are read horizontally.

Based on the data in Table 4 can be seen that the watering interval s_3 (5 days) on the growing media composition m_3 (soil, compost, cocopeat; 1:1:1) produces the highest dry weight compared to other treatments.This shows that the condition of growing media composition $m_3$with watering every 5 days is an optimal condition for the growth of potato plants.The properties of cocopeat that has highwater holding capacity so that the 5-day watering interval can still meet the water needs of potato plants.

Table 3: Effect of watering intervals and growing media compositions on plant height, stomatal conductance, leaf relative water content, and shoot-root ratio

Treatments	Observations			
	Plants height (cm)	Stomatal Conductance (mmol/m^{2}s)	Leaf Relative Water Content (%)	Shoot-root Ratio
s_1 = watering interval of 3 days	46.43 a	307.86 c	56.09 a	6.15 a
s_2 = watering interval of 4 days	45.34 a	253.36 b	59.09 a	6.03 a
s_3 = watering interval of 5 days	42.93 a	184.40 a	56.74 a	5.77 a
m_1 = soil, compost, husk charcoal (1:1:1)	40.55 a	236.57 ab	54.14 a	5.19 a
m_2 = soil, compost, husk charcoal (2:1:1)	47.53 b	229.59 a	56.09 a	5.71 a
m_3= soil, compost, cocopeat (1:1:1)	46.36 b	256.97 bc	58.06 ab	5.83 ab
m_4 = soil, compost, cocopeat (2:1:1)	45.14 ab	271.04 c	60.93 b	7.19 b

Mean values in each column with the same letter are not significantly different (p=0.05) based on DMRT

Number of Stolons Per Plant, Stolon Tuberization, Number of Tubers Per Plant

Variance analysis results showed no interaction between watering intervals and growing media compositions onnumber of stolons per plant, stolon tuberization, number of tubers per plant.

Table 5: Effect of watering intervals and growing media compositions onnumber of stolon per plant, stolon tuberization, number of tubers per plant

Treatments	Observations		
	Number of Stolons Per Plant	Stolon Tuberization (%)	Number of Tubers Per Plant (knol)
Watering intervals			
s_1	5.87	112.01	6.55
s_2	5.92	113.03	6.65
s_3	6.06	98.40	5.86
Growing media compotisitions			
m_1	5.54	112.23	6.13
m_2	6.48	105.83	6.70
m_3	5.91	105.35	6.23
m_4	5.87	107.86	6.35

Based on the data in Table 5 shows that the watering intervals and growing media compositions did not significantly affect the number of stolons.The number of stolons formed is affected by high air temperatures at the experiment location. Planting potatoes in a location that has a temperature that exceeds the optimum temperature for potato plants will cause an increase in the hormone gibberellins in the lower stem tissue which stimulates the division and development of new cells for the formation of stolons so that the number of stolons increases[15].

High air temperatures promote the synthesis of gibberellin in the plantthus the stolon tips continue to grow longer and prevent the stolon from developing into tubers so that not all stolons become tubers[15]. Hormone gibberellins also stimulated the growth of vegetative parts faster so that the photosynthate that is produced leaves are not focused on the formation and enlargement of tubers[16].

The number of stolons formed determines the number of tubers and is influenced by the absorption of water and nutrients from the growing media for the process of photosynthesis[17].The number of tubers produced in each treatment is still lower than the description of the Medians variety which states that the number of tubers produced by the Medians variety can reach 10 tubers/plants.

Tubers Weight Per Plant

The result of variance analysis showed that there is an interaction between watering intervals and growing media compositions to tubers weight per plant.

Table 6: Effect of watering intervals and growing media compositions on tubers weight per plant (g)

Watering Intervals	Growing Media Compositions			
	m_1	m_2	m_3	m_4
s_1	161.15 a	352.48 a	218.20 a	376.20 b
	A	C	B	C
s_2	148.27 a	361.93 a	164.90 a	283.40 a
	A	B	A	B
s_3	134.41 a	317.23 a	320.05 b	297.29 a
	A	B	B	B

Mean values in each column with the same letter are not significantly different (p=0.05) based on DMRT. Small case letters are read vertically and capital letters are read horizontally.

Based on the analysis results in Table 6 shows that the watering interval of 3 days on growing media composition of the soil, compost, cocopeat (2:1:1) produces the highest tubers weight per plant compared to other treatments. Tubers are the storage of the accumulation of photosynthates from the leaves. One of the factors that affect the photosynthesis process is water as one of the main ingredients in the process of photosynthesis. The fulfillment of water needs of the plants causes photosynthesis process run optimally to produce a greater amount of photosynthate for tubers filling.

Percentage of Potatoes Qualified and Not Qualified Market

Based on the results of statistical analysis showed there was no interaction between watering intervals and growing media compositions on percentage of potatoes qualified and not qualified market.

Table 7: Effect of watering intervals and growing media compositions onpercentage of potatoes qualified and not qualified market

Treatments	Observations	
	Potatoes Qualified Market (%)	Potatoes Not Qualified Market (%)
s_1 = watering interval of 3 days	96.86	3.14
s_2 = watering interval of 4 days	93.95	6.05
s_3 = watering interval of 5 days	90.93	9.07
m_1 = soil, compost, husk charcoal (1:1:1)	93.76	6.24
m_2 = soil, compost, husk charcoal (2:1:1)	97.10	2.90
m_3= soil, compost, cocopeat (1:1:1)	94.24	5.76
m_4 = soil, compost, cocopeat (2:1:1)	90.56	9.44

Potatoes qualified are tubers that have no physical damage due to harvest activities or pest attacks. Potatoes not qualified is found commonly because it greening and brown rot caused by *Ralstonia solanacearum*, but the percentage is smallof about 3% -9 %.This is because the soil around the base of potatoes was hilled up to prevent greening on the tubers and the sterilization of growing media before planting to kill harmful microorganisms.

Percentage of Potatoes Based on Quality Grade

Based on the results of statistical analysis showed there was no interaction between watering intervals and growing media compositions onpercentage of potatoes based on quality grade.

Table 8: Effect of watering intervals and growing media compositions onpercentage of potatoes based on quality grade

Treatments	Potatoes Based on Quality Grade (%)					
	XL	A	B	C	Baby	Out Grade
s_1	0.00	0.00	1.08	2.11	14.80	82.01
s_2	0.00	0.00	0.00	1.87	15.21	82.92
s_3	0.00	0.00	0.97	2.44	22.73	73.86
m_1	0.00	0.00	0.74	0.00	14.83	84.43
m_2	0.00	0.00	0.56	3.09	18.81	77.55
m_3	0.00	0.00	0.00	2.29	18.01	79.70
m_4	0.00	0.00	1.44	3.19	18.66	76.72

Grading the potato based on the weight of the tubers is as follows: Class XL (> 200 g), Class A (120-200 g), Class B (80-119 g), Class C (50-79 g), and Baby class (25-49 g)[18].

Based on the data in Table 8shows that each treatment did not produce tubers class XL and A, and just a few tubers which belong on class B and C. The percentage of tubers in the Baby class also not much only ranged between 10% to 34%. The fulfillment of water needs of the plants causes photosynthesis process run optimally to produce photosynthate in larger quantities for tubers filling.

Most of the potatoes that are produced are not included in the grading criteria because the weights produced are too small as much as 59-90%. It is because of the high air temperature. High temperature resulted in higher gibberellins content in potato plants, thereby stimulated stolon extension and inhibited stolon develops as a result of the small potato produced[19].

4. Conclusion

1) Interaction between watering interval 5 days on the growing media composition of the soil, compost, cocopeat (1:1:1) produced the highest dry weight.
2) Interaction between watering interval 3 days on the growing media composition of the soil, compost, cocopeat (2:1:1) produced the highest tubers weight per plant.
3) Growing media composition of the soil, compost, cocopeat (1:1:1) and soil, compost, cocopeat (2:1:1) gave the highest average value to the stomatal conductance, the leaf relatives water content, and shoot-root ratio.

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